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INFLUENCE OF WORK HISTORY ON THE
DEVELOPMENT OF EFFECTIVE RESEARCHERS¹

G. Barry Graves² by
===== and Donald G. Marquis³

January 1967

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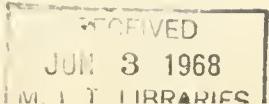
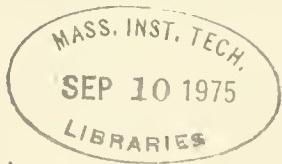
¹This paper is based on results obtained by G.B. Graves and reported in his S.M. thesis when he was a Fellow in the Sloan Program of Executive Development, 1961-62. The research was supported in part by a grant to the MIT Sloan School from the National Administration for Space and Astronautics (NsG-235).

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INFLUENCE OF WORK HISTORY ON THE
DEVELOPMENT OF EFFECTIVE RESEARCHERS

Abstract

This study was undertaken to determine if the nature of the work assignments in a research laboratory influence the development of technical competence of individuals.

Two samples of graduate engineers and scientists engaged in aeronautics and astronautics research were compared. One sample was selected on the basis of outstanding technical competence while a second sample was more nearly average in technical competence but similar to the first in other respects. Questionnaires and follow-up interviews were used to obtain information regarding the primary technical assignments undertaken by the 12 individuals in each sample. Information was obtained on 215 tasks, or assignments, which represented 76 percent of the technical effort of the men during a period that averaged 14 years. The time period was divided into quarters in order to determine the effect of the earlier assignments on the later technical competence.

Although their work assignments did not differ during the second half of their careers, the superior men, compared to the average men, had assignments during the first half of their work history which were more frequently in applied research and advanced development, and less frequently in development and test work. They reported more assignments calling for greater use of advanced theory. Also, they reported a greater percentage of their new technical ideas in areas not directly concerned with the immediate tasks. This suggests that the climate experienced by these men was more favorable to imaginative and creative thinking. The results indicate that important and significant differences existed between the experiences of the two samples. However, these cannot now be interpreted as cause and effect since differences in technical competence may have been recognized early and have resulted in the assignment of the tasks. In any event, the nature of the early assignments was associated with the subsequent development of technical competence.

INFLUENCE OF WORK HISTORY ON THE DEVELOPMENT OF EFFECTIVE RESEARCHERS

The importance for research personnel of aptitude, training, and experience as well as a favorable environment and leadership are well recognized. However it also seems pertinent to consider the influence of work assignments on the development of individual competence, since these tasks represent a major and continuing portion of the career researcher's training. With better understanding of this influence it may be possible to improve the overall technical competence of research personnel whenever there is sufficient latitude in making assignments or in encouraging work in specific areas.

A comparison of the work histories of two samples of research personnel was undertaken with the cooperation of the National Aeronautics and Space Administration's Langley Research Center at Hampton, Virginia. This study concerns personnel whose duties are primarily technical and is intended to reveal any significant differences in work history between individuals who were considered to have outstanding technical competence and others who were more nearly average in technical competence but similar in other respects.

It is recognized that many factors other than those associated with work assignments can have critical effects on the two samples selected for study. Considerable care was therefore taken to avoid the effects of any particular supervisor, subordinate organizational group, technical discipline, or clique which might exist.

There are approximately 3,200 persons employed at Langley, and about 1,000 of these are scientific and engineering professionals assigned to nine major research divisions. Almost all of these individuals are college graduates and from 20 to 60 in each division have been employed at this location more than ten years. Six of the nine research divisions were involved in this investigation. The supervisors of these six divisions were asked to select a minimum of two

individuals who have been employed for 10 years or longer and who were technically outstanding, and an equal number who were more nearly average in technical performance. Personnel with extensive administrative or management duties were not included in the study. Supervisory personnel were not excluded from the study because of the acknowledged technical competence of many of them, but they were not considered if they supervised more than six persons without the aid of an assistant or associate who handled much of the administrative work and permitted them to function primarily in a technical capacity. In no instance did more than two individuals have the same immediate supervisor.

The samples each consisted of 12 individuals. Those selected on the basis of outstanding technical ability will be referred to as Group 1. Group 2 consists of the 12 individuals with average technical ability. The two groups are very similar in age, total experience, and educational background, but differ in salary as one would expect. Summary information on the two groups is given in Table 1.

Method

Information on each person's work experiences was obtained first by means of a questionnaire and second in a follow-up interview. On the basis of preliminary interviews it was found that reference material on past assignments, such as technical reports and file memoranda, was very helpful in reviewing the work and particularly in fixing the time periods. A listing of each person's technical publications was used for this purpose.

The questionnaire identified the primary technical assignments over a period of ten years or longer, and obtained information on a number of items regarding each assignment.

The respondents were asked to specify for each assignment in his entire work career (1) the type of task they were given, (2) how they divided their work effort among four types of activity, (3) the theoretical and practical

TABLE 1. CHARACTERISTICS OF TWO SAMPLES SELECTED FOR STUDY

Characteristic	Group 1 (high)	Group 2 (average)
Mean age (years)	38.2	38.0
Total Experience (years)	14	13.9
Technical Discipline		
Aeronautical Engr.	7	9
Mechanical Engr.	2	3
Electrical Engr.	1	
Physics	2	
Advanced degree	2	1
Mean salary	\$13,666	\$11,855
Number of supervisors	8	0

nature of the task, (4) the pressure experienced on the task, (5) the interest in the task, (6) outside professional associations, (7) the development of new technical competences and technical study undertaken, and (8) the proportion of new technical ideas concerned with the immediate task, a related field, or a remote field.

Upon examination of the time periods and the duration of the tasks, it seemed reasonable to divide each individual's work career into four equal periods (the average quarter being $3\frac{1}{2}$ years long) and simply assign the task to the particular quarter in which the majority of the effort took place. The subjects reported on 215 tasks constituting 76 percent of their total technical effort during the period studied. This period averaged 14 years per researcher and represented the entire professional career for 9 of the 12 individuals in each group.

The characteristics of the two groups were first examined for the entire time period and then for each of the four quarters of the work history. Comparable data for each quarter shows that the greatest differences between the two groups are in the earliest half of the time period. Both the types of assignments and the division of the work effort are significantly different.

Results

Classification of Tasks

In the questionnaire the subject was asked to classify each of his assignments as one of the following:

- a. Testing
- b. Development
- c. Advanced Development
- d. Applied Research
- e. Basic Research

Figure 1 shows the distribution of the work effort of the two groups among these five types of assignments. In the initial half of the time period the two

groups differed markedly in the amount of test, development, advanced development, and applied research undertaken. Group 1, the high rated group, spent much more effort in applied research and less effort in test and data collection.

Table II

Comparison of Two Groups in Number of Applied Research Tasks Undertaken During the Initial Half of the Time Period

	Group 1	Group 2	Totals
Number of applied research tasks	9	2	11
Number of other tasks	<u>35</u> 44	<u>45</u> 47	<u>80</u> 91

Table II shows that on the basis of the total number of tasks undertaken by the two groups in the two groups in the initial half of the time period, the difference in the amount of applied research performed by each group is significant at the .05 level. It was not possible to test for significance in the case of test and data collection assignments, since only three such assignments were undertaken by the members of Group 1 during the entire period studied.

In the second half of the time period the differences between the two groups are much less. The differences for the total time period are clearly caused by the extreme difference during the initial half.

Types of Work Required by Each Task

For every task the individual indicated the division of his work effort among four types of activity by reporting the percentage of his time spent on each of the following:

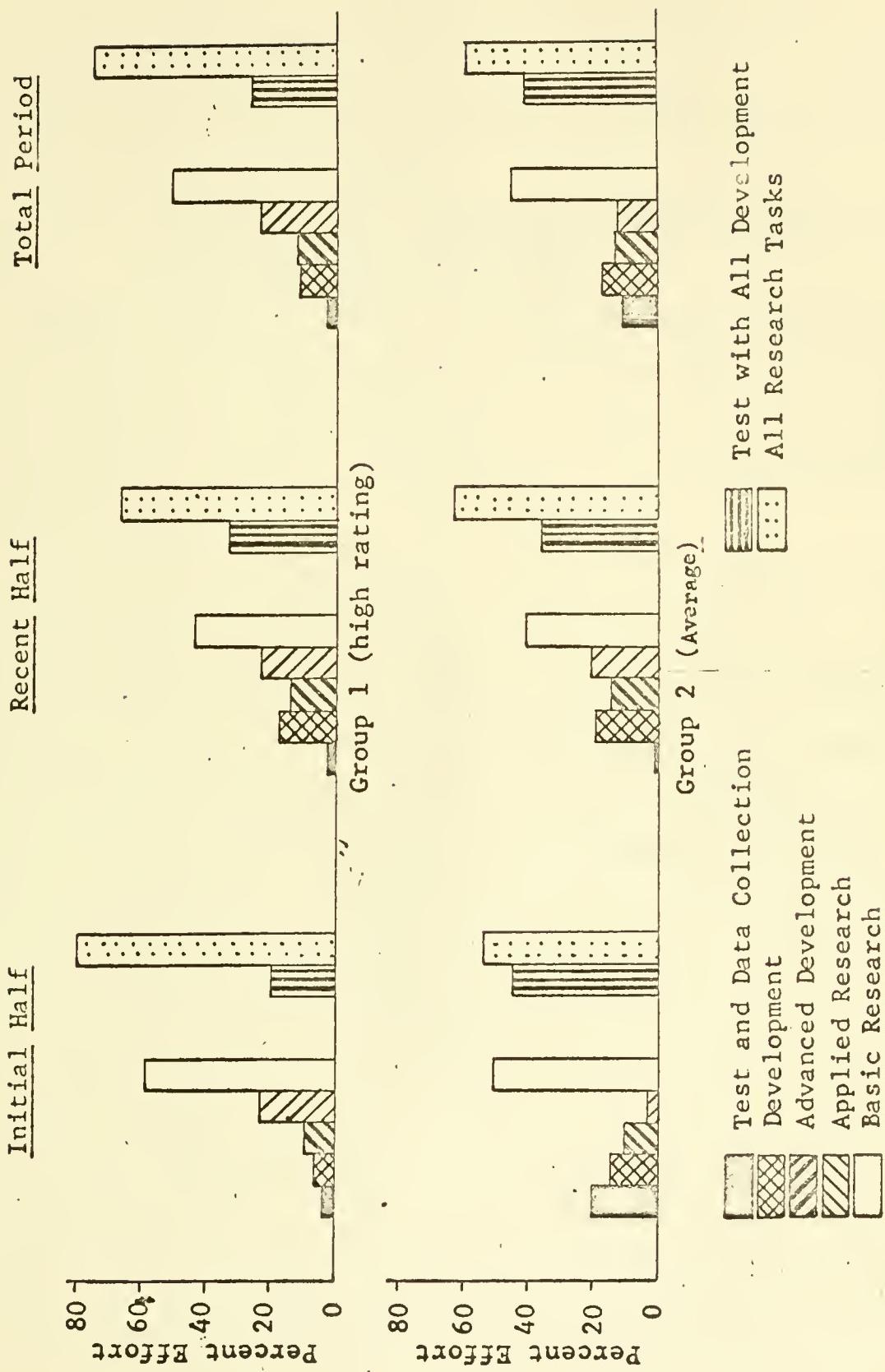


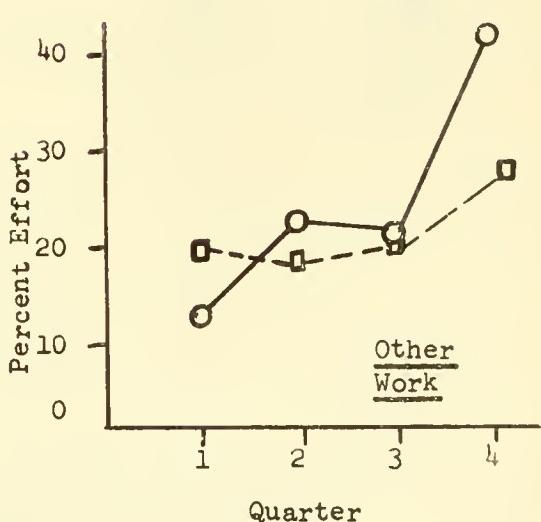
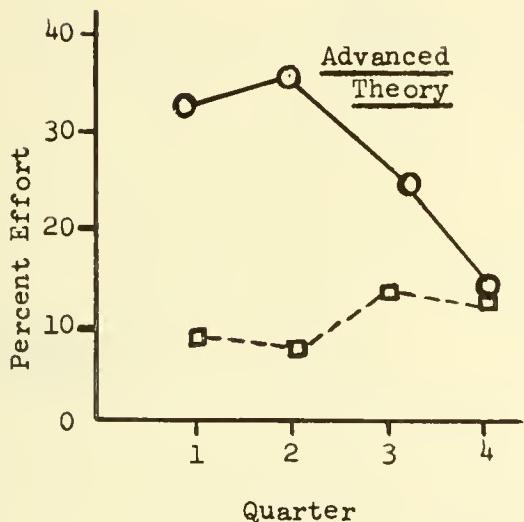
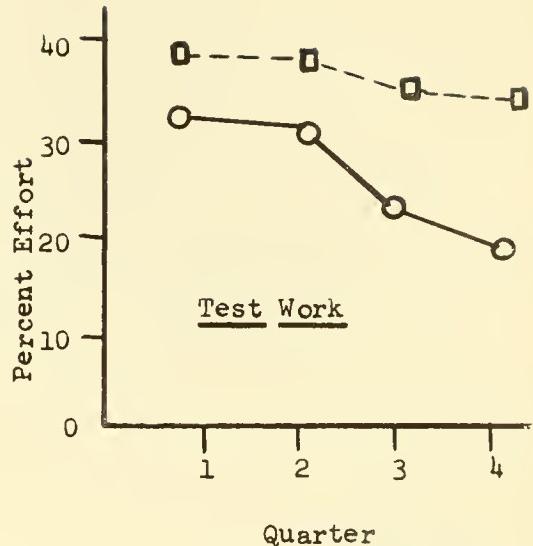
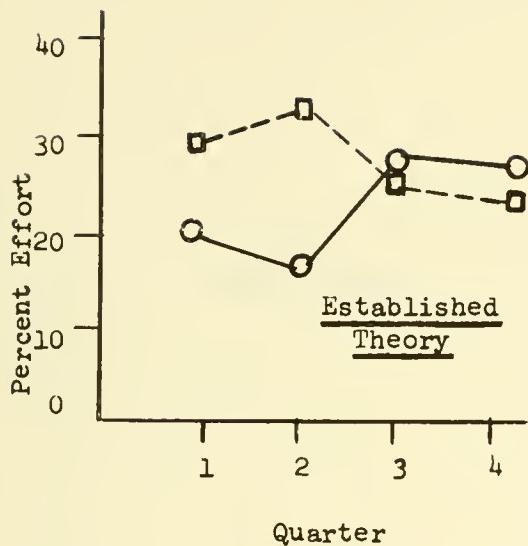
FIGURE 1. EFFORT ON VARIOUS TYPES OF ASSIGNMENTS DURING EACH HALF OF TIME PERIOD AND OVER COMPLETE TIME PERIOD.

- a. Design work or studies using established theories
- b. Tests and data collection
- c. Theoretical study and analysis of problems where established theory was inadequate.
- d. Other work (such as contacts with supporting groups, administrative matters, report preparation, etc.)

Figure 2 presents the division of effort among the four types of work. Differences between the two groups for the initial half and the second half of the time period are clear except in the case of "other work". Group 1 reported using a greater amount of advanced theory and a lesser amount of established theory during the initial half.

Figure 3 compares the two groups in effort spent on advanced theory for three different groupings of tasks during both halves of the time period. Again the greater use of advanced theory by Group 1 during the initial half of the time period is quite evident. It is likely that the decline in the corresponding figure for the recent half resulted from the need for members of Group 1 to devote more effort to administrative duties and other items included under "other work". Figure 2 indicates that the percentage of effort in this category increased more for Group 1 than for Group 2, although the differences were not significant.

Table III shows that Group 1 used advanced theory to a much greater extent than Group 2 in every category except that of testing and data collection. The difference was significant at the .05 level, or better, in both quarters of the initial half of the time period, in the case of all research tasks in the initial half, and for the basic research assignments over the complete time period. In comparison to Group 1, Group 2 made more use of established theory and test work in most categories, but the differences were not as significant as those for the use of advanced theory. During the recent half of the time period, however, the difference between the two groups in the amount of test work done was substantial.



○—○ Group 1 (high)
□---□ Group 2 (average)

FIGURE 2. Comparison of Two Groups in Proportion of in Established Theory, Test Work, Advanced Theory, and Other Work in Each Quarter of Work History

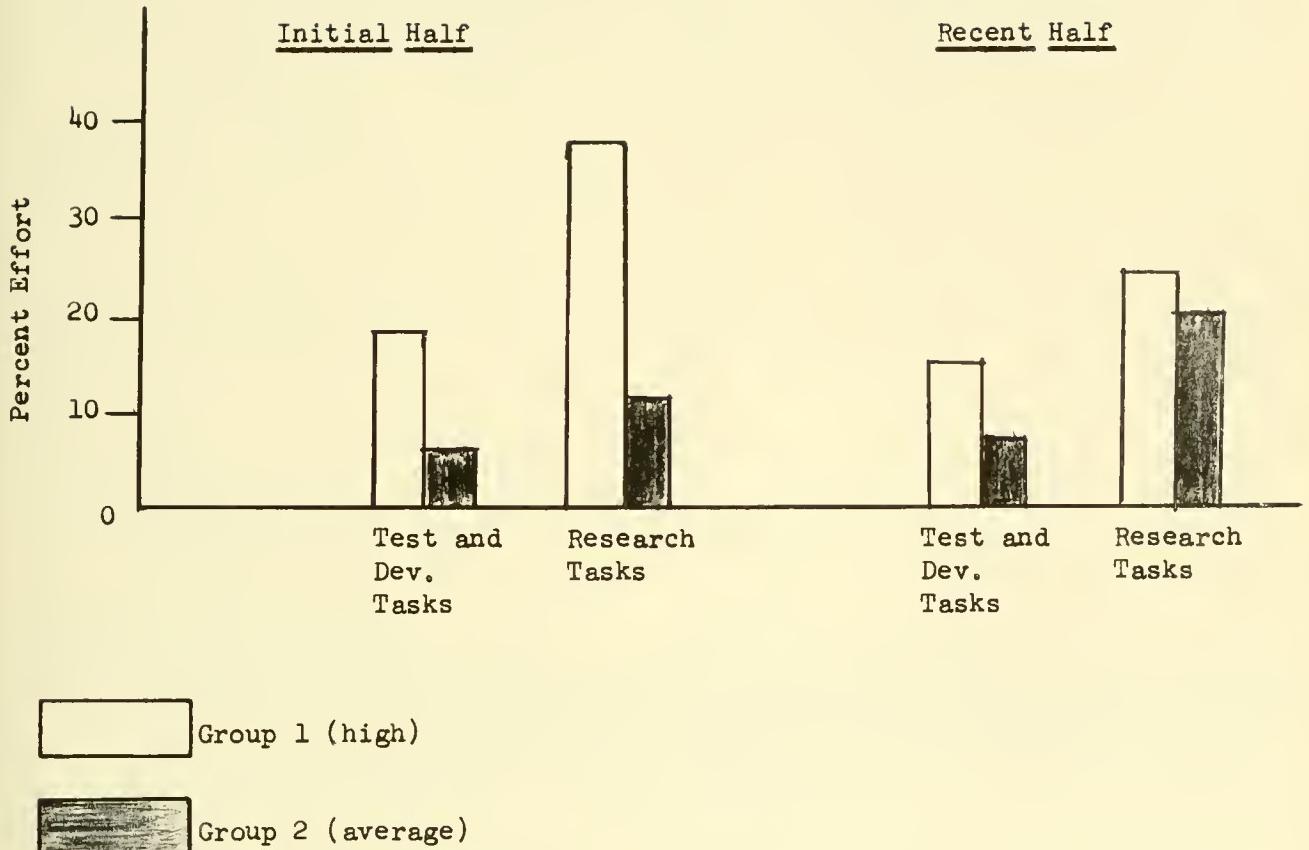


Figure 3. Proportion of tasks involving application of advanced theory during each half of time period and indication of significance.

and significant. Group 2 engaged in tasks of which 33 percent required a greater than average amount of test work. The corresponding figure for Group 1 is 13 percent.

Percentage of Tasks Using Greater Than Mean* Amount of Advanced Theory

<u>Sample</u>	<u>Group 1</u>	<u>Group 2</u>	<u>Significance</u>
Complete Time Period, All Tasks	41	19	.001
Initial Half, All Tasks	57	15	.001
Quarter 1 (initial), All Tasks	55	12	.01
Quarter 2, All Tasks	58	18	.05
All Research Tasks, Initial Half	64	19	.005
Basic Research Tasks, Complete Time Period	45	23	.05

*Mean values based on the entire time period with both groups combined.

Outside Professional Associations

Two questions concerned the researcher's outside professional associations while engaged in his tasks. If outside associations were developed in carrying out an assignment, he was asked to state the number of such associations. The responses of the two groups are compared in Table IV. Group 1 indicated that a greater number of its tasks required outside associations, but the differences in this case were not significant. Significant differences did appear in the total number of associations made during the most recent quarter of the time period, during the recent half, and over the complete period:

Table IV

Percentage of Tasks Involving More Than the
Mean Number of Outside Associations

<u>Sample</u>	<u>Group 1</u>	<u>Group 2</u>	<u>Significance</u>
Complete Time Period, All Tasks	32	13	.001
Recent Half, All Tasks	38	16	.05
Quarter 4 (most recent), All Tasks	41	14	.05

These differences probably reflect an increased number of outside associations by the supervisory personnel in Group 1 during the recent half of the time period studied.

New Technical Ideas

Each subject was asked to indicate the percentage of his new and important technical ideas that concerned (1) the immediate task at hand, (2) the same technical field as the task though not directly related to the task, (3) technical fields remote from those involved with the task. Table V presents the results.

That Group 1 reported a higher percentage of new ideas in related fields and in remote fields is quite consistent with other findings. The difference is significant both for the initial half and for the total time period.

Additional significant differences appear in Table V which shows the percentage of tasks associated with more than the mean number of technical ideas concerning related fields and remote fields. Once again the significant differences occur in the initial half of the time period. This suggests that some feature of the assignments may have had an importnat influence on the production of new ideas in fields not directly concerned with the immediate tasks. Present analysis of the data suggests that the relative effort spent in applied research and in test and data collection bears relation to the production of ideas. This supports the

hypothesis that the proportion of applied research tasks must be above some minimum level to obtain a greater number of advanced ideas.

Table V

Percentage of Tasks Having Greater
Than Mean Number of Technical Ideas

<u>Item and Sample</u>	<u>Group 1</u>	<u>Group 2</u>	<u>Significance</u>
Ideas--Related Field			
Complete Time Period, All Tasks	29	13	.005
Initial Half, All Tasks	36	4	.001
Quarter 1 (initial), All Tasks	45	0	.001
Initial Half, All Research Tasks	50	4	.05
Ideas--Remote Field			
Complete Time Period, All Tasks	20	3	.001
Initial Half, All Tasks	27	0	.001
Initial Half, All Research Tasks	30	0	.01

CONCLUSIONS

The most important and significant differences found by comparing the tasks undertaken by the two groups of researchers appeared in the initial half of the time period and showed that those with outstanding technical competence had undertaken more work in the form of applied research tasks in contrast to development assignments and test and data collection.

In the division of work effort, the men with outstanding technical competence found it necessary to make greater use of advanced theory in carrying out their assignments. Significant differences were also found in the nature of new technical ideas. The group with greater competence had a much greater percentage of new ideas in areas not directly concerned with the immediate task.

From the preceding discussions it is evident that important differences between the groups existed in the types of work assignments, the use of advanced theory in accomplishing the work, and the percentage of new technical ideas in fields not directly concerned with the immediate task. In each of these items the differences during the first half of the work history are most clear. In the use of advanced theory and in the nature of new technical ideas, significant differences were found in the initial quarter of the work histories.

It is quite clear that the tasks in the initial periods in the work histories showed differences between the two groups which may be important and which require explanation. One could argue that the individuals in Group 1 were recognized early as having technical competence which was above average, and that this resulted in the observed work assignments. This line of thinking rests on the assumption that personnel with greater technical competence were required more often for applied research than for other types of assignments, such as testing and development. The assumption seems a reasonable one, for research tasks usually relate to immediate problems of considerable difficulty and the pressure for their solution is relatively high. Basic research assignments also require high technical

competence but are subject to less pressure; a man can be assigned to such work without as great immediate demand for effective performance. One would thus expect that the subjects of the study experienced greater pressure in applied research tasks than in others. They did report somewhat greater pressure on applied research than on basis research, but the distinction is not clear between applied research and other types of assignments.

One might also expect that most of the applied research would be assigned to persons in Group 1 during the second half of the time period. Figure 1 shows that this is not the case. Conceivably the character of the work changed such that applied research tasks no longer held the same priority in work assignments. In view of the increased amount of "other work" reported by members of Group 1 during the second half, it seems more likely that they assumed supervisory duties to an extent that prevented them from continuing to take such a large share of the applied research assignments.

The factors considered in this study indicate that work assignments may have an important influence on the development of effective research workers. Further research may show more conclusively that a substantial amount of work in applied research, as contrasted to testing and developmental tasks, is in itself a positive influence on the growth of technical competence.

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